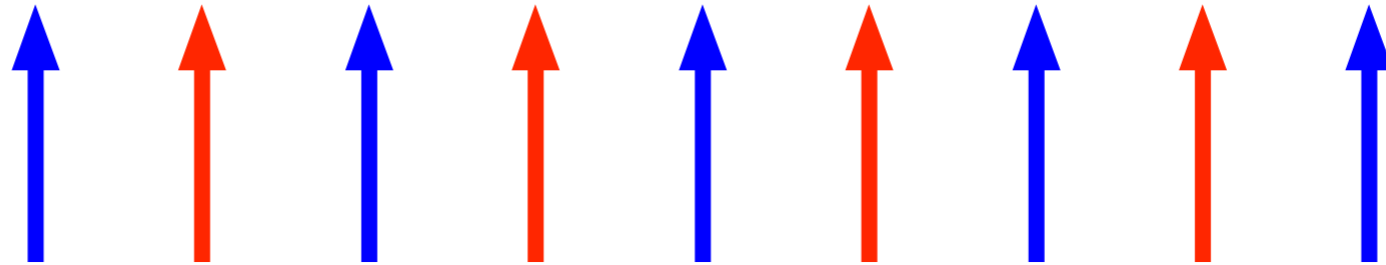


Vorzeichen der Austauschkopplung

$$U = \lambda M_A M_B$$

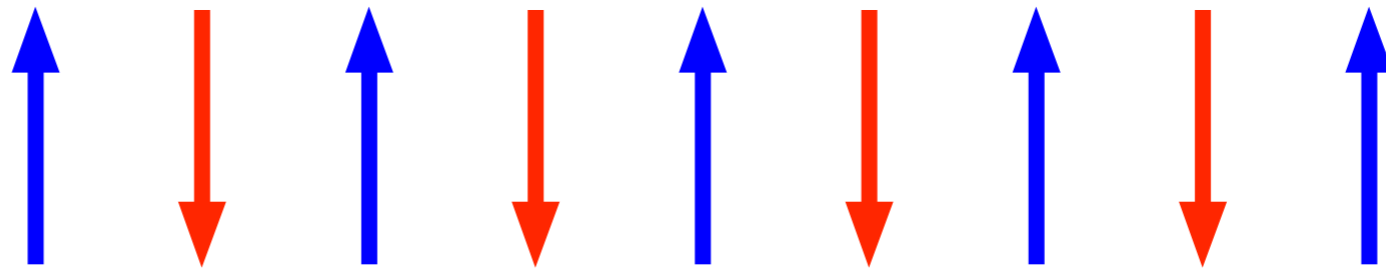
für $\lambda > 0$:

Ferromagnetisch



$U > 0$

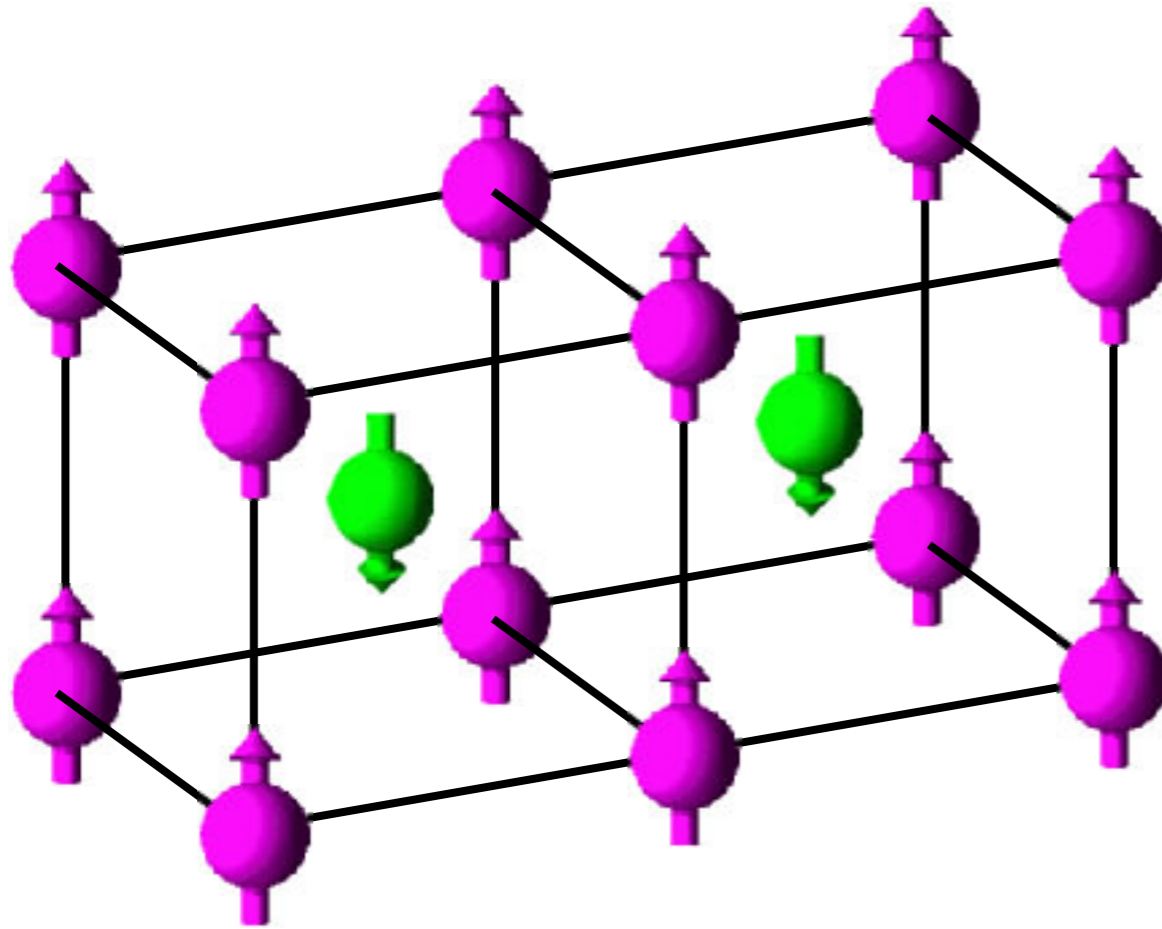
Antiferromagnetisch



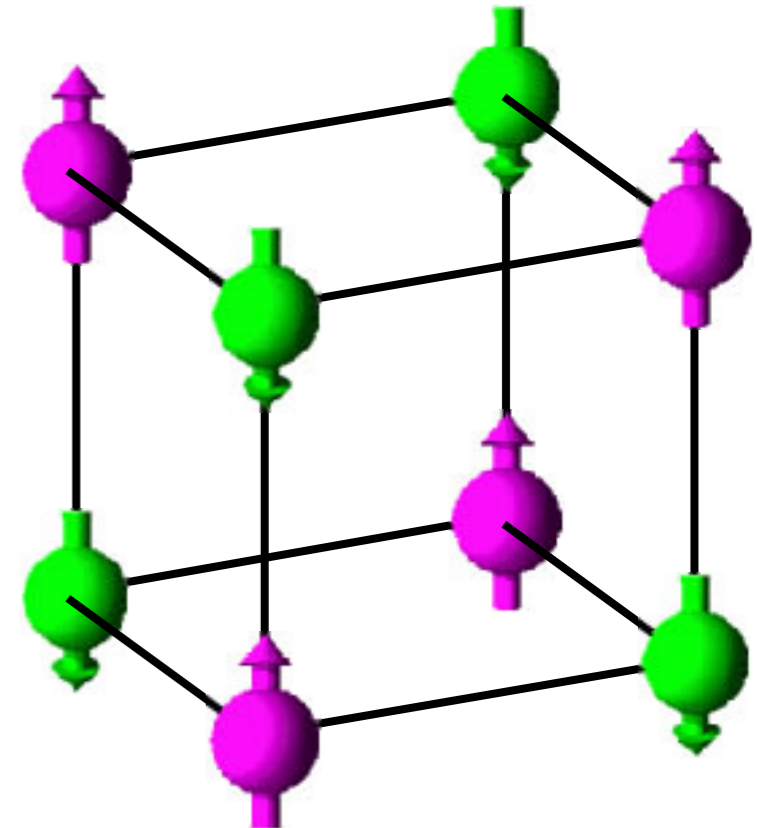
$U < 0$

Antiferromagnetische Ordnung

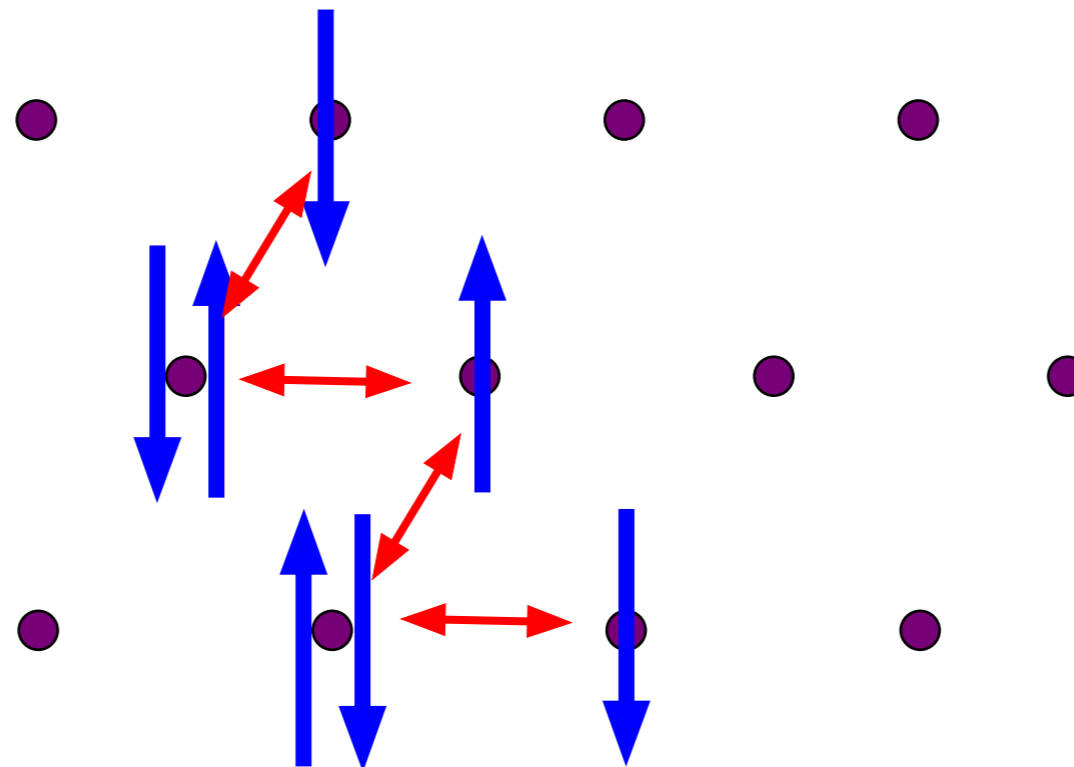
bcc



sc



hexagonales Gitter
in 2D

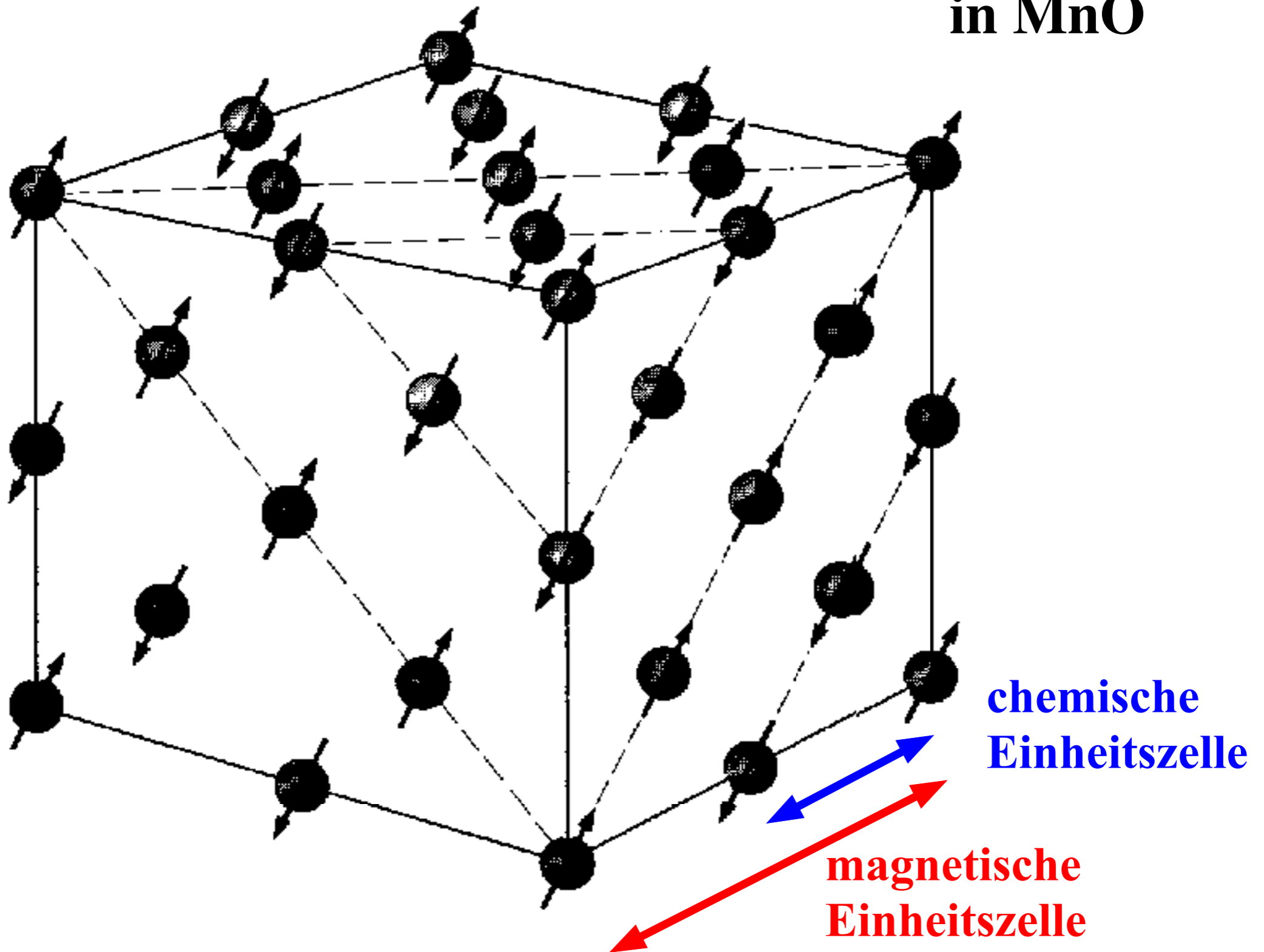


Frustration

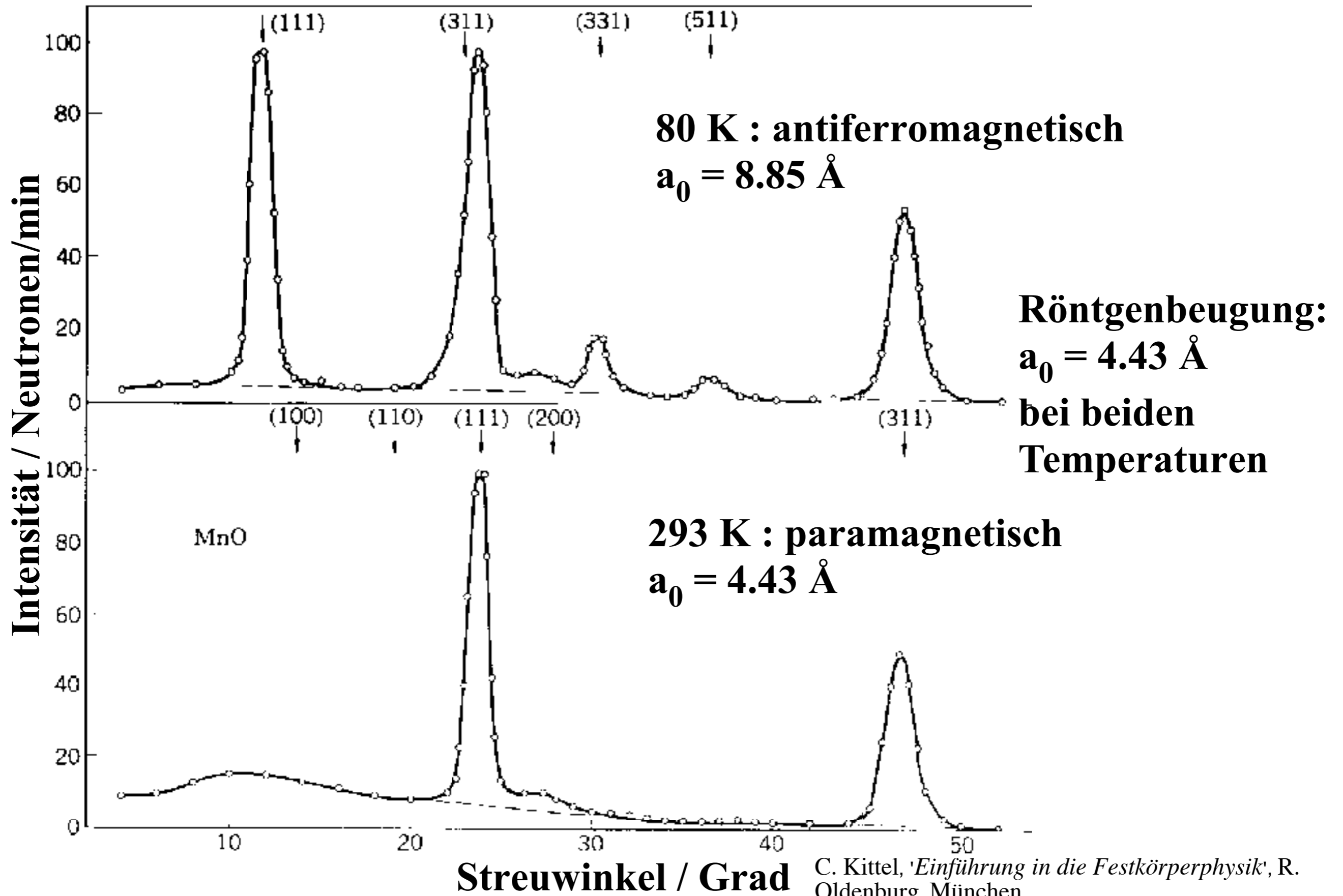
Antiferromagnetische Ordnung

in MnO

Mn²⁺
O²⁻ nicht
dargestellt



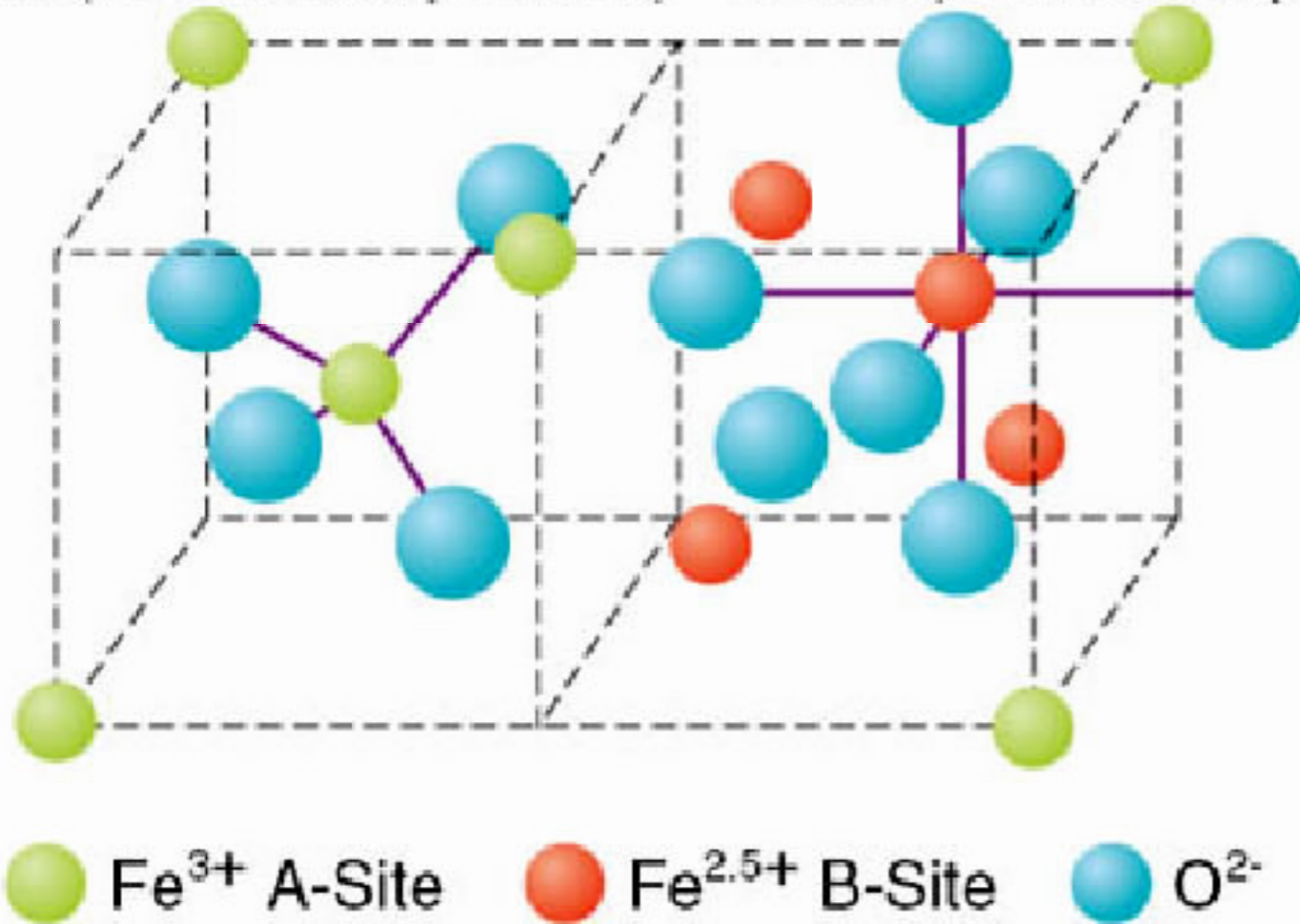
Magnetische Neutronenbeugung



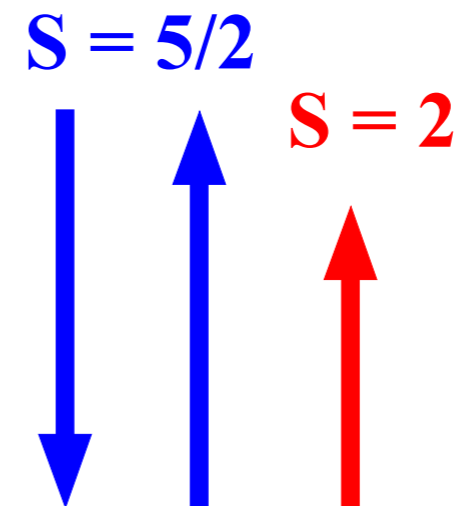
Magnetit



1/4 unit cell of inverse spinel structure
A site (tetrahedral position) B site (octahedral position)



Magnetische Ordnung:

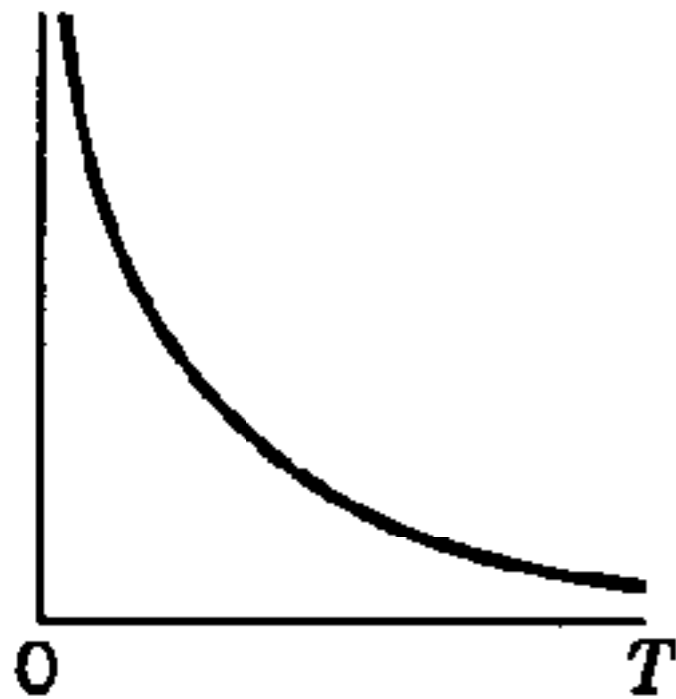


Temperaturabhängigkeit

der Suszeptibilität

Paramagnetismus

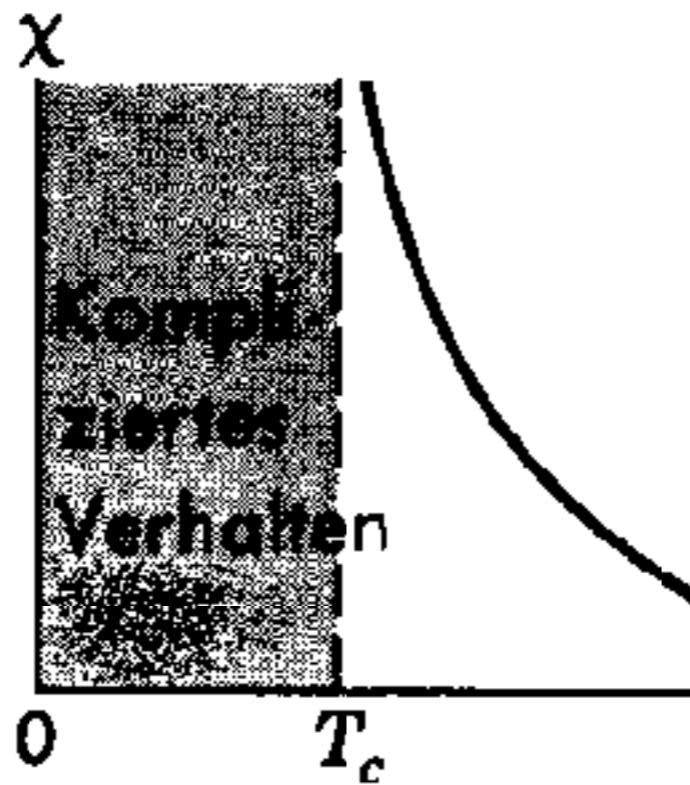
Suszeptibilität



$$\chi = \frac{C}{T}$$

Curie-Gesetz

Ferromagnetismus

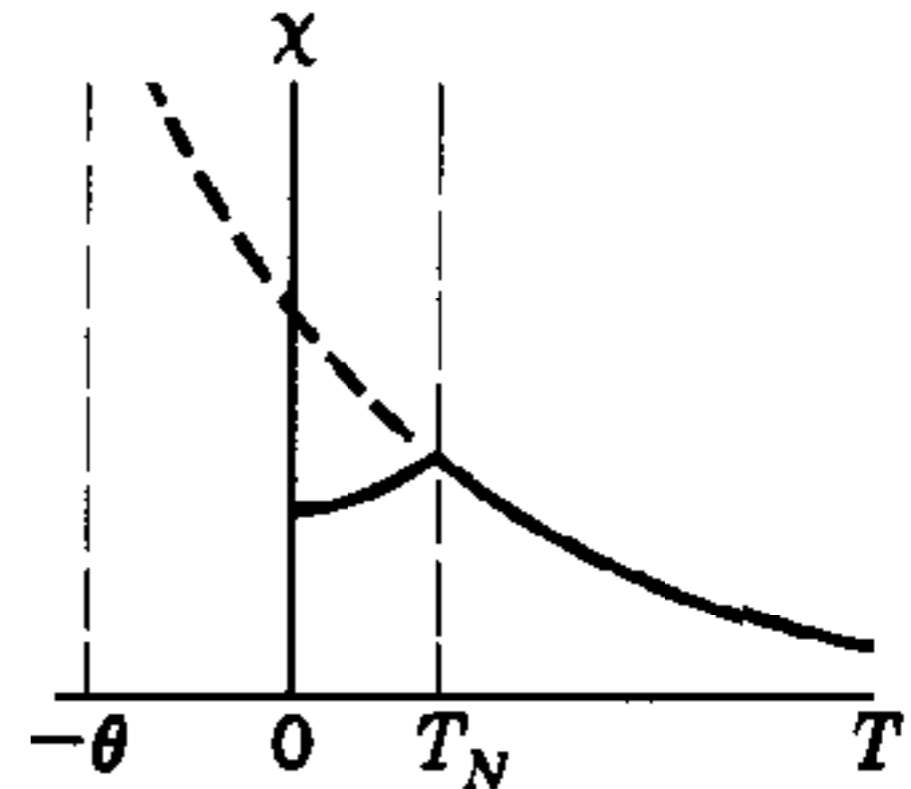


$$\chi = \frac{C}{T - T_c}$$

Curie-Weiß-Gesetz

$$(T > T_c)$$

Antiferromagnetismus



$$\chi = \frac{2C}{T + \theta}$$

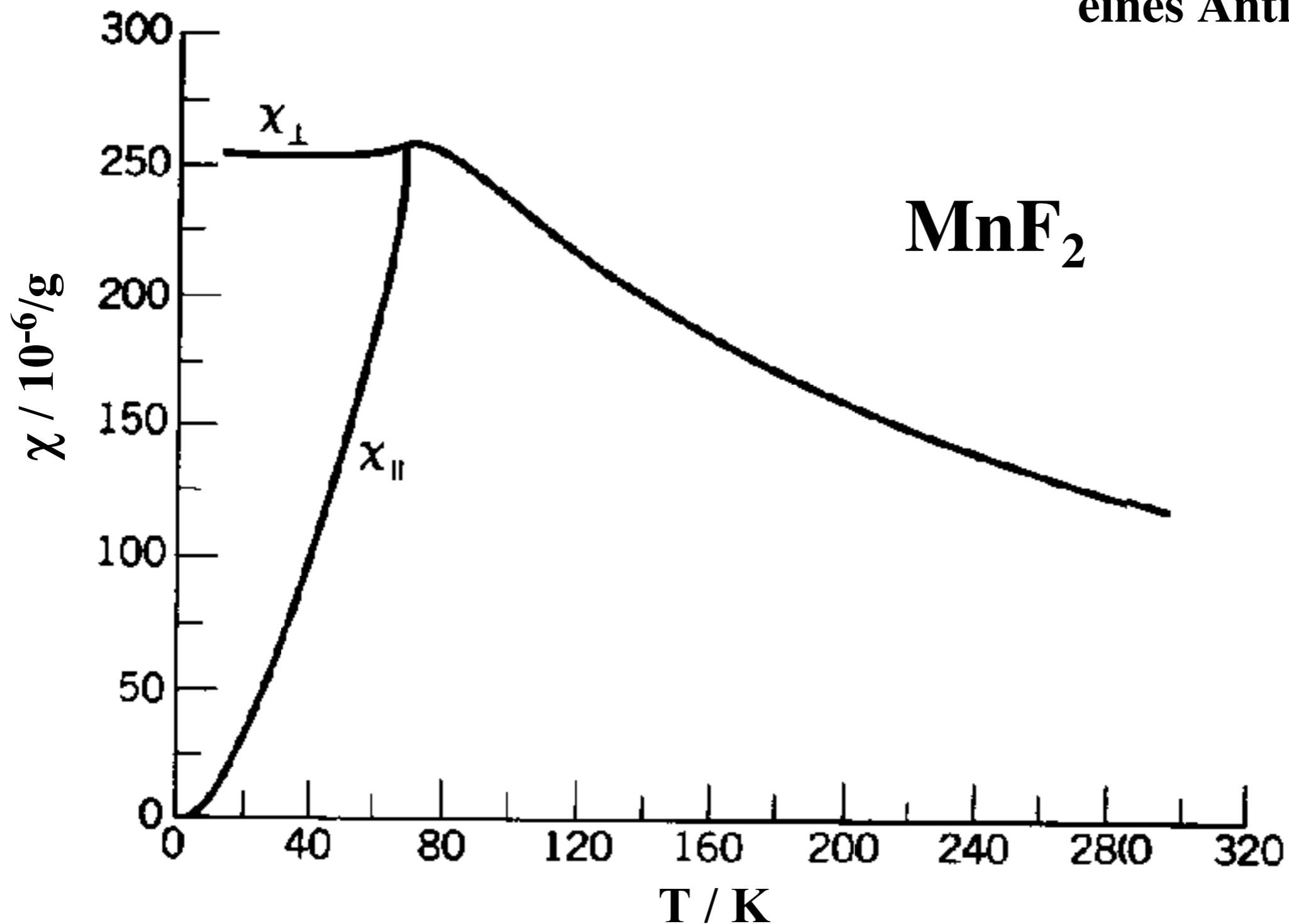
$(T > T_N)$

Antiferromagnetische Kristalle

Material	Paramagnetisches Ionengitter	Übergangstemperatur T_N in K	Curie-Weiß θ in K	$\frac{\theta}{T_N}$	$\frac{\chi(0)}{\chi(T_N)}$
MnO	fcc	116	610	5,3	2/3
MnS	fcc	160	528	3,3	0,82
MnTe	hex. Schicht	307	690	2,25	
MnF ₂	bc tetr	67	82	1,24	0,76
FeF ₂	bc tetr	79	117	1,48	0,72
FeCl ₂	hex. Schicht	24	48	2,0	<0,2
FeO	fcc	198	570	2,9	0,8
CoCl ₂	hex. Schicht	25	38,1	1,53	
CoO	fcc	291	330	1,14	
NiCl ₂	hex. Schicht	50	68,2	1,37	
NiO	fcc	525	~2000	~4	
Cr	bcc	308			

Anisotroper Paramagnetismus

eines Antiferromagneten



Magnetische Suszeptibilität von Manganfluorid (MnF_2) parallel und senkrecht zur tetragonalen Achse. (Nach S. Foner.)

C. Kittel, 'Einführung in die Festkörperphysik', R. Oldenbourg, München

Magnonendispersion

